Carbonatite exsolution from evolved mantle melts: evidence from inclusions in green-core clinopyroxene

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We present evidence for exsolution of magnesian carbonatitic and sulfidic melt from a highly evolved silicate melt. All three melts are trapped as inclusions in green cores of clinopyroxene from a basanitic volcano located on the northern shoulder of the Eger Graben near the Czech-German border.

Green-core clinopyroxenes (cpx) are common as xeno- or megacrysts in primitive alkali basalts and may show considerable chemical variability. They may have different origins but are usually considered to have crystallized from evolved magmas due to the typically low Mg# = molar $Mg/(Mg+Fe^{tot})$. In our samples the Mg# in cpx is between 0.4 and 0.6. The silicate melt inclusions are alkali-rich (9-14 wt.%) and contain 50-55 wt.% SiO_2, placing them in the tephri-phonolitic and phonolitic fields. The Mg# in the melt inclusions is typically below 0.1. The general composition of the melt inclusions is similar to tephri-phonolite and phonolite volcanoes from the area with the exception of somewhat higher Fe contents. Carbonatitic melt droplets with predominantly magnesitic composition and typically less than 5% calcium carbonate component are found as inclusions in the silicate melt inclusions. The textures indicate that both phases were simultaneously trapped in liquid state together with minor amounts of a third melt of sulfidic composition. The heterogeneously trapped multi-phase inclusions suggest that exsolution of the three melts took place simultaneously with rapid growth of cpx, suggesting that the exsolution may have been the driving force for reaching cpx saturation.

Rare earth element partitioning between the silicate melt and the cpx are used to test chemical equilibrium between the two phases. Cpx-melt pairs are then used for thermobarometry to constrain the depth of formation of the green-core cpx and the carbonatite exsolution. We propose a simple two-step model involving formation of a highly evolved magma at depth from which carbonatite exsolves and cpx crystallizes and subsequent uptake of these phenocrysts by a more primitive magma which serves as a mode of transportation to the surface.